VOL. XXI. September, 1894. No. 9.

THE
Journal
OF
Nervous and Mental Disease.

Original Articles.

A STUDY OF THE TEMPERATURE SENSE.[1]

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THE purpose of this study of the temperature sense has been:

1. To determine the relative sensibility of the skin to heat and cold in the different parts of the body.
2. To determine the lowest temperature that will give a sensation of heat, and the highest temperature that will give a sensation of cold when applied to the surface of the body.
3. To determine the temperature which gives pain with heat or with cold, when applied to the different parts of the body.
4. To determine the relation, if any, between the number of the "hot spots" and the sensitiveness to heat in the different parts of the body, and between the number of "cold spots" and the sensitiveness to cold in the different parts of the body.
5. To determine the modifying influence of heat and cold on the temperature sense.
6. To determine the "reaction time" to heat and cold in the different parts of the body.

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[1] Read by title at the Meettng of American Neurological Association, Washington, D. C., May 30, 1894.

The subjects used in the experimentations were thirty healthy young men between the ages of twenty and thirty-five years. The temperature of the room in which the experiments were conducted was kept at 80° F., and all conditions of the body were kept as nearly as possible the same in all the cases.

The surface temperature of the different parts of the body, especially the temperature of the feet and hands, is an element of importance which needs to be kept in mind in determining the sensation produced by the application of any temperature to the surface of the body.

The tests made in this series of experiments numbered over five thousand. In each case each lateral half of the body was divided into fifteen different areas, as follows:

1. Feet; 2. Inside of leg; 3. Outside of leg; 4. Inside of thigh; 5. Outside of thigh; 6. Abdomen; 7. Chest; 8. Front part of neck; 9. Face; 10. Upper arm; 11. Forearm; 12. Hands; 13. Back part of neck; 14. Dorsal spine; 15. Lower spine and sacral region.

These parts are numbered as above in Figs. 1 and 2, which see on next page.

To determine the relative sensibility of these different areas of the body to heat and to cold, the tests were made in the thirty different subjects by the use of test-tubes containing water at 0°C., 5°C., 10°C., 15°C., 20 C., 25°C., etc., up to 70°C. The sensation produced in the different areas of the body was noted in each case, with the different temperatures, and comparisons were made.

Of the thirty subjects tested it was found that a few were very much more sensitive to heat and cold than the majority, while a few others were much less sensitive to heat and cold than the majority. Besides this, there were slight variations in the different cases. One fact, however, showed itself very prominently: Each of the fifteen different areas of the body tested occupied a certain position of its own in the scale of sensibility to heat and to cold. The parts that were most sensitive to heat

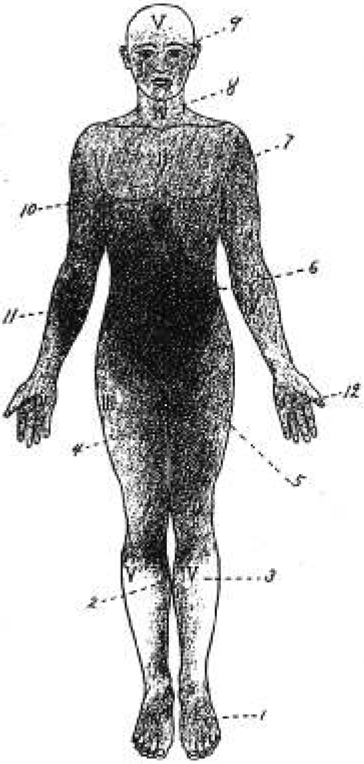

FIG. 1.

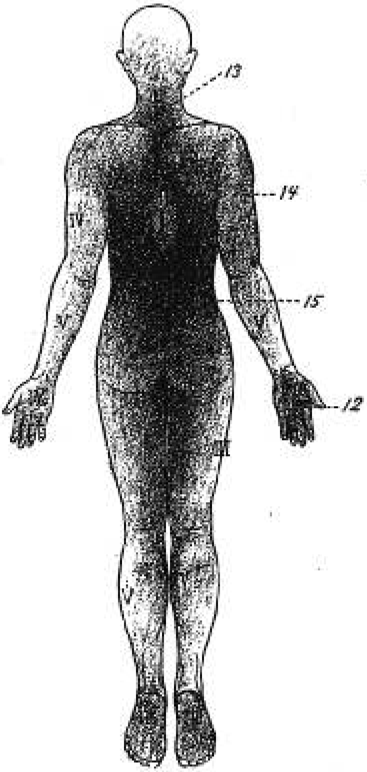

FIG. 2.

Figs. 1 and 2 illustrate the relative sensibility of the skin to heat and cold, the deeper shading representing the most sensitive parts to both heat and cold, and the lighter shading the less sensitive parts to heat and cold.

The Roman numerals also represent the relative sensibility of the different parts. The lower numerals are placed on the most sensitive parts and the higher on the less sensitive parts.

The Arabic numerals refer to different divisions of the surface of the body.

were likewise most sensitive to cold. The parts of the body, given in the order of their sensibility, are as follows:

I. Abdomen, sacral and lumbar regions of the spine, with the intervening space on each side of the body.

II. Inside of thigh, chest, cervical spine, and upper dorsal spine.

III. Inside of arm, outside of thigh, lower dorsal spine, and the soles of the feet.

IV. Front of neck, inside of forearm, palm of hand, inside of leg, and top of foot.

V. Outside of forearm, outside of leg, and forehead.

The soles of the feet are more sensitive than the palms of the hands. The palm of the hand and the back of the hand are about equally sensitive.

Figs. 1 and 2, on page 551, illustrate the degree of sensibility of the skin to heat and to cold, the deeper shading indicating the most sensitive parts, and the lighter shading, the less sensitive parts to heat and to cold. The Roman numerals on the charts indicate the relative sensibility of the different parts of the body. The lower numerals are placed over the most sensitive parts, and the higher over the less sensitive parts. Those parts having the same numerals have the same, or very nearly the same, sensibility to heat and to cold.

To determine the lowest and highest temperatures which give rise to a sensation of heat or of cold, when applied to the skin, in each of the different parts of the body, ten subjects were tested in the different areas of the body shown in Figs. 1 and 2. The tests were made with test-tubes containing water at varying temperatures between 33°C. and 41°C. In the majority of the cases, in nearly all of the fifteen different parts of the body tested a temperature of 33°C. gave a sensation of cold, and a temperature of 41°C. gave a sensation of heat. Temperatures between 33° and 41° gave different results in different cases, and in different parts of the surface of the body in the same case. A detailed report of the different results obtained, with temperatures of 33°C., 35C., 39°C., and 41°C. respectively, is shown in a tabulated form on next page.

It will be noticed from this tabulated report that nearly all the tests made with a temperature of 33°C. produced a sensation of cold; while all the tests made with

TABLE OF TEMPERATURE REACTIONS IN TEN DIFFERENT SUBJECTS TO DETERMINE THE HIGHEST TEMPERATURE GIVING A SENSATION OF COLD AND THE LOWEST TEMPERATURE GIVING A SENSATION OF WARMTH IN THE FIFTEEN AREAS OF THE SURFACE OF BODY, MENTIONED BELOW.

(*Tests were made with glass test-tubes containing water, at the different temperatures given below.*)

Temperature in centigrade degrees		30°	33°	35°	39°	41°
PARTS OF BODY.		No. of reactions	No. of reactions	No. of reactions	No. of reactions	No. of reactions
1. Feet	Warm	0	0	4	9	10
	Cool	9	9	4	1	0
	Pressure	1	1	2	0	0
2. Lower leg—inside	Warm	0	0	1	3	9
	Cool	10	6	4	2	0
	Pressure	0	4	5	5	1
3. Lower leg—outside	Warm	0	0	1	4	9
	Cool	10	9	4	2	0
	Pressure	0	1	5	4	1
4. Thigh—inside	Warm	0	0	1	4	10
	Cool	10	10	5	3	0
	Pressure	0	0	4	3	0
5. Thigh—outside	Warm	0	0	0	4	10
	Cool	10	10	5	4	0
	Pressure	0	0	5	2	0
6. Abdomen	Warm	0	0	0	3	10
	Cool	9	10	5	4	0
	Pressure	1	0	5	3	0
7. Chest	Warm	0	0	0	3	10
	Cool	9	9	7	4	0
	Pressure	1	1	3	3	0
8. Front part of neck	Warm	0	0	0	4	10
	Cool	9	10	6	1	0
	Pressure	1	0	4	5	0
9. Face	Warm	0	0	0	3	10
	Cool	9	10	4	3	0
	Pressure	1	0	6	4	0
10. Upper arm	Warm	0	0	1	3	10
	Cool	10	9	3	3	0
	Pressure	0	1	6	4	0
11. Forearm	Warm	0	0	1	2	10
	Cool	10	9	3	3	0
	Pressure	0	1	6	5	0
12 Back part of neck	Warm	0	0	0	2	10
	Cool	10	9	5	2	0
	Pressure	0	1	5	6	0
13 Upper spine	Warm	0	0	0	2	10
	Cool	10	9	6	3	0
	Pressure	0	1	4	5	0
14. Lower spine	Warm	0	10	0	2	10
	Cool	10	0	6	3	0
	Pressure	0	0	4	5	0
15. Hands	Warm	0	0	1	2	10
	Cool	10	9	2	3	0
	Pressure	0	4	7	5	0

a temperature of 41°C. gave a sensation of heat; and the tests made with temperatures of 35°C. and 39°C. gave in some cases a sensation of warmth, in others pressure, and in others cold.

Another series of tests was made with ten different subjects, by dipping the whole hand into water of different temperatures, for the purpose of determining the highest temperature which produced a sensation of cold, and the lowest temperature which produced a sensation of heat. It was found in every case that a temperature of 1°F. above the surface temperature of the hand produced a sensation of heat, and a temperature of 1°F. below the surface temperature of the hand produced a sensation of cold. The surface temperature of the hand was noted in all these different tests; and it was found to be from 90°F. to 95°F. on the back of the hand, and from 92°F. to 97°F. on the palm of the hand, with the hand closed.

From these two series of tests it was demonstrated that the temperatures which give rise to sensations of heat or cold depend on the surface temperature of the part tested, and also on the amount of surface exposed to heat or to cold. They also show that a sensation of cold produced by a temperature near the surface temperature of the part tested is more readily detected than a sensation of heat produced by a temperature near that of the surface of the part tested; at least such is the case when the tests are made with test tubes.

The water in the test-tube and the water into which the whole hand was dipped, produced a sensation of cold at practically the same temperature—a temperature of about 33°C. A temperature of 34°C. gave a sensation of heat when the whole hand was exposed, while with the test-tube it required a temperature of 39°C. to 41°C. in order to produce a sensation of heat.

The results of these tests would seem to indicate that the surface of the body is more sensitive to temperature below its own surface temperature than to temperatures above it.

To determine the highest temperature at which sensations of cold are painful in the different parts of the surface of the body, ten subjects were tested in all the different parts of the body, shown in Figs. 1 and 2, with temperatures varying from 0°C. to 20°C. The tests were made with test-tubes containing water. From these tests it was found that 0°C. temperature in every case produced pain in all parts of the body; and in a number of cases pain was produced with a temperature of 5°C. In the parts of the body that are most sensitive, cold is felt as pain at a higher temperature than in parts that are less sensitive. The different reactions to these various temperatures is shown here in tabulated form, page 556.

To determine the lowest temperature at which heat will cause pain in the various parts of the body, a series of tests similar to those just described with reference to cold was made, with temperatures varying from 55°C. to 70°C. In the majority of cases a temperature of 65° C. produced pain in all the different parts of the body. Heat was felt as pain at lower temperatures in the most sensitive parts. A detailed report of these tests is shown in the tabulated form, page 557.

Tests were also made on ten subjects to determine the highest temperature at which cold sensations become painful, and the lowest temperature at which heat sensations become painful, when the whole hand is exposed. These tests were made with a Fahrenheit thermometer. It was found that a temperature of from 40°F. or 10°C. to 42°F. or 11°C. was the highest temperature at which cold would cause pain in each case; and a temperature of from 120° to 123°F. or 49° to 51°C. was the lowest temperature at which heat would cause pain in every case. A very interesting fact noticed in connection with the experiments was that in nearly every case pain was not produced until the hand had been exposed from 15 to 30 seconds. The sensation during this time was that of cold, pain then taking the place of cold, and lasting from one to two minutes and then disappearing. The sensation of cold was

TABLE OF TEMPERATURE REACTION IN TEN DIFFERENT SUBJECTS TO DETERMINE THE HIGHEST TEMPERATURE AT WHICH COLD WILL CAUSE PAIN IN THE FIFTEEN AREAS OF THE BODY MENTIONED BELOW.

(*Tests were made with test-tubes containing water at the different temperatures given below*)

Temperature in centigrade degrees .		0°	5°	10°	15°	20°
PARTS OF BODY.		No. of reactions	No. of reactions	No. of reactions	No. of reactions	No. of reactions
1. Feet	Cold	0	3	8	9	Cool in the least sensitive parts and cold in the most sensitive parts.
	Unpleasantly cold	1	5	2	1	
	Pain	9	2	0	0	
2. Lower leg — inside . . .	Cold	0	2	5	9	
	Unpleasantly cold	1	8	5	1	
	Pain	9	0	0	0	
3. Lower leg — outside . .	Cold	0	2	4	8	
	Unpleasantly cold	0	8	4	2	
	Pain	10	0	2	0	
4. Thigh — inside	Cold	0	2	3	8	
	Unpleasantly cold	0	7	6	2	
	Pain	10	1	1	0	
5. Thigh — outside	Cold	0	1	0	6	
	Unpleasantly cold	0	5	5	4	
	Pain	10	4	5	0	
6. Abdomen .	Cold	0	1	5	6	
	Unpleasantly cold	0	4	5	4	
	Pain	10	5	0	0	
7. Chest . . .	Cold	0	1	2	6	
	Unpleasantly cold	0	4	4	4	
	Pain	10	5	4	0	
8. Front part of neck . . .	Cold	0	4	3	7	
	Unpleasantly cold	0	2	4	3	
	Pain	10	4	3	0	
9. Face. . . .	Cold	0	3	4	7	
	Unpleasantly cold	1	5	4	3	
	Pain	9	2	2	0	
10. Upper arm	Cold	0	3	4	8	
	Unpleasantly cold	0	4	4	2	
	Pain	10	3	2	0	
11. Forearm . .	Cold	0	3	2	8	
	Unpleasantly cold	0	5	7	2	
	Pain	10	2	1	0	
12. Back part of neck . . .	Cold	0	4	3	8	
	Unpleasantly cold	0	4	6	2	
	Pain	10	2	1	0	
13 Upper spine	Cold	0	2	2	6	
	Unpleasantly cold	0	2	6	4	
	Pain	10	6	2	0	
14. Lower spine	Cold	0	2	2	6	
	Unpleasantly cold	0	2	4	4	
	Pain	10	6	4	0	
15. Hands . . .	Cold	0	6	2	9	
	Unpleasantly cold	0	2	5	1	
	Pain	10	2	3	0	

TABLE OF TEMPERATURE REACTION IN TEN DIFFERENT SUBJECTS TO DETERMINE THE LOWEST TEMPERATURE AT WHICH HEAT WILL CAUSE PAIN IN EACH OF THE FIFTEEN AREAS OF THE BODY, MENTIONED BELOW.

(Tests were made with glass test-tubes containing water at the different temperatures given below.

Temperature in centigrade degrees . . .		55°	60°	65°	70°
PART OF BODY.		No. of reactions	No. of reactions	No. of reactions	No. of reactions
1. Feet	Hot	Warm in the least sensitive parts, unpleasantly warm in the most sensitive parts.	7	0	Painful all over surface of body.
	Unpleasantly hot		1	3	
	Pain		2	7	
2. Lower leg—inside	Hot		7	0	
	Unpleasantly hot		1	3	
	Pain		2	7	
3. Lower leg—outside	Hot		7	0	
	Unpleasantly hot		1	3	
	Pain		2	7	
4. Thigh — inside . .	Hot		6	0	
	Unpleasantly hot		2	3	
	Pain		2	7	
5. Thigh — outside .	Hot		6	0	
	Unpleasantly hot		2	3	
	Pain		2	7	
6. Abdomen	Hot		5	0	
	Unpleasantly hot		3	3	
	Pain		2	7	
7. Chest	Hot		7	0	
	Unpleasantly hot		2	3	
	Pain		1	7	
8. Front part of neck	Hot		7	0	
	Unpleasantly hot		2	3	
	Pain		1	7	
9. Face	Hot		7	0	
	Unpleasantly hot		1	3	
	Pain		2	7	
10. Upper arm	Hot		7	0	
	Unpleasantly hot		1	3	
	Pain		2	7	
11. Forearm	Hot		6	0	
	Unpleasantly hot		2	3	
	Pain		2	7	
12. Back part of neck	Hot		6	2	
	Unpleasantly hot		2	3	
	Pain		2	5	
13. Upper spine . . .	Hot		3	3	
	Unpleasantly hot		5	2	
	Pain		2	5	
14. Lower spine . . .	Hot		3	3	
	Unpleasantly hot		5	2	
	Pain		2	5	
15. Hands	Hot		6	0	
	Unpleasantly hot		2	3	
	Pain		2	7	

again felt and continued while the hand was exposed. The same thing was observed with reference to heat; but, as a rule, the time of exposure before pain was produced was slightly longer, and the period during which pain was experienced was a little shorter, than with the cold. When the sense of pain passed away, the sensation of heat remained while the hand was exposed. Temperatures a few degrees higher or lower would cause pain the instant the hand was placed in the water, and would continue for a longer period than with the temperatures given above.

By a comparison of the tests made for pain with these different temperatures, it will be seen that the temperature that will cause pain when applied to the surface of the body, depends largely on the amount of the surface exposed, and to some degress on the length of time of the exposure. With the test-tube applied to the surface of the body, a temperature of 0° C. was necessary to cause pain; while, with the whole hand exposed, a temperature of 10°C. was sufficient to bring the same results, and this was even more painful than that produced by the test-tube, and the pain was of an entirely different character. Also, with reference to heat, a temperature of 65°C. was necessary to produce pain with the test-tube, while a temperature of 50°C. or 120°F. caused pain when the whole hand was exposed.

To determine the relation between the number of "cold spots," and the sensitiveness to cold in the different parts of the body, and between the number of "hot spots," and the sensitiveness to heat in the different parts of the body, tests were made as follows:

Five different healthy persons were taken, and circles two centimetres in diameter were marked out in each of the fifteen different areas of the surface of the body, as shown in Figs. 1 and 2. A brass rod tapered to a fine point was the instrument used to detect the "cold spots" and the "hot spots." In testing for the "cold spots" the instrument was cooled by placing it in ice water; and in testing for "hot spots ' the instrument was heated by placing it in water at 120° to 140°F. The whole surface within each of these different circles in the different parts of the body was carefully tested to detect the number of "cold spots" and the number of "hot spots" in each circle. These were marked with ink, and the number in each of the fifteen different parts of the body shown in the figures counted in each of the five cases tested. By comparing the number of "cold spots" in each circle of any part of the body with the sensitiveness to cold in that part of the body, it was found that the part of the body most sensitive to cold did not contain a greater number of "cold spots" than a circle located in some other part of the body, less sensitive to cold. The parts of the body that were less sensitive to cold frequently had more "cold spots" than parts that were more sensitive to cold. That is, the tests seemed to prove the fact that the sensitiveness to cold in the different parts of the body did not depend upon the number of "cold spots" within any given area, or within the circle marked outin these parts. This is contrary to the idea held by Goldschneider and others who claim that in the parts of the body where the skin is most sensitive to heat or to cold the corresponding class of spots is relatively frequent. The number of "cold spots" in each circle on each of the different parts of the body is shown in Fig. 3.

In these tests it was observed that there were two classes of "cold spots,"—one class which, when stimulated with moderate cold, gave a sensation of icy cold; another class which felt cool when stimulated with moderate cold; *i. e.*, the same object may feel cool to one spot and icy cold to another.

The sensitiveness to heat in any part of the surface of the body did not have a relative number of "hot spots." The parts most sensitive to heat frequently had no more "hot spots" than others less sensitive to heat. It was proven that the "hot spots," when stimulated with cold, gave a sensation of cold; and the "cold spots," when stimulated with heat, gave a sensation of heat; so

FIG. 3.

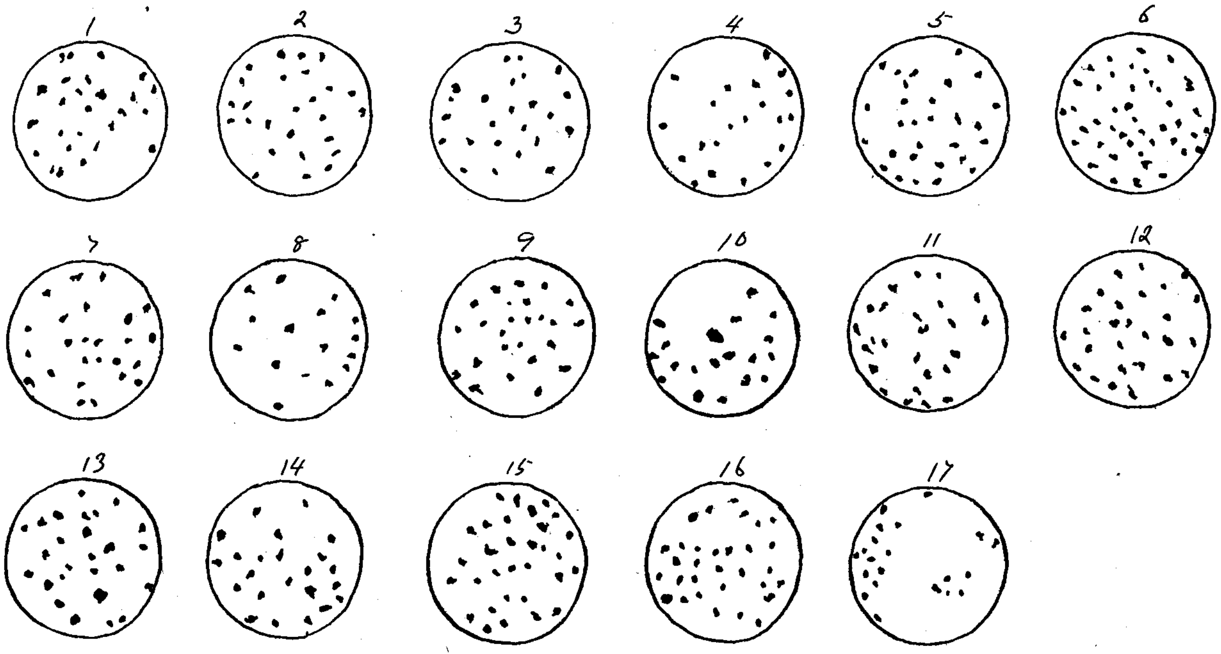

Fig. 3 represents the number of cold spots in a circle two centimetres in diameter in each of seventeen different parts of the body.

1. Forearm, outside; 2. Forearm, inside; 3. Upper arm, outside; 4. Upper arm, outside; 5 Cheek; 6. Forehead; 7. Chest; 8. Abdomen; 9. Thigh, inside; 10. Thigh, outside; 11 Leg, inside; 12. Leg, outside; 13. Upper part of foot; 14. Neck, in front; 15. Upper spine; 16. Lower spine; 17. Back of the hand.

that we are led to conclude, contrary to the opinions of Blix and Goldschneider, but in harmony with the teaching of Dessoir, that there are not two separate sets of end organs, one for heat and one for cold, but rather that the sensation of heat or cold depends upon the kind of stimulus operating on a given point, and not on the point irritated. And further, if one hand be placed in water of 20°C. and held for five minutes, then placed in water of 25°C., a sensation of warmth is produced; while to the hand not previously placed in the water of 20°C., a sensation of cold is produced by water at 25°C.

And again, if one hand is placed in water of 40°C. for five minutes, and then in water of 35°C., the water of 35°C. gives a sensation of cold to the hand previously placed in water of 40°C. But to the hand not previously placed in the water of 40°C., a temperature of 35°C. gives a sensation of warmth.

How are we to account for the fact just stated—that the same objective temperature may cause a sensation of both heat and cold in the same individual, if we hold to the theory of two separate end organs, one capable of being stimulated by cold and not by heat, and the other capable of stimulation by heat and not by cold?

Then, again, "hot" and "cold" are, in physics, only relative terms. It is not at all natural to suppose that absolutely different apparatus, distinct and separate, each occupying a local position of its own, should be required for these two sensations which are developed by the same form of energy in different quantities. We therefore conclude that there are not two sets of end organs concerned with the temperature sense, and consequently not two independent senses, one of heat and one of cold.

Heat and cold are to the temperature sense what light and darkness are to the sense of sight. Cold is the absence of heat, as darkness is the absence of light.

To determine the modifying influences of heat and cold on the temperature sense, tests were made with ten subjects by placing the hand in water of five different temperatures; viz., at 10°C., 20°C., 30°C., 40°C., and 50°C., making a series of fifty tests. One hand was exposed to each of these temperatures for five minutes, then both hands were placed in water five degrees above, and again in water five degrees below, the temperature of the water in which the hand had been held for five minutes; and the sensation in each case compared with the sensations in the hand that had not been subjected to any temperature outside its own normal before these tests were made. A summary report of these tests in the ten different cases for each of the different temperatures is as follows:

1. Right hand is held in water of 10°C. for five minutes. Both hands are then placed in water of 5°C. Both hands feel cold in the water of 5°C., but the sensation of cold is greater in the right hand, which has previously been exposed to a temperature of 10°C. In water of 15°C. the right hand feels for a moment slightly warm, then cold, but not unpleasantly cold. The left hand feels colder than the right hand. The sensation in the left hand is distinctly cold, while the sensation in the right hand, which follows that of warmth, is only slightly cold.

2. Right hand is placed in water of 20° C. for five minutes. Both hands are then placed in water of 15° C., which gives a sensation of cold to both hands; but the sensation of cold is greater in the right hand, which has previously been exposed to a temperature of 20° C. Water of 25° C. gives a sensation of warmth to the right hand and a sensation of cold to the left.

3. The right hand is placed in water of 30° C. for five minutes. Both hands are then placed in water of 25° C. The sensation to both hands is that of cold. The water of 25° C. feels slightly less cool to the right hand than to the left. The difference is slight and rather indistinct. Water of 35° C. gives a sensation of warmth to both hands. The feeling of warmth is greater to the right hand at 35° C. than to the left.

4. The right hand is placed in water of 40° C. for five

minutes. Both hands are then placed in water of 35° C. The water at 35° C. is cold to the right hand, which has previously been exposed to a temperature of 40° C., and warm to the left hand, which has not been subjected to any temperature outside its own normal previous to the test. Water of 45° C. is warm to both hands, but is warmer to the right hand than to the left.

5. The right hand is placed in water of 50° C. for five minutes. Both hands are then placed in water of 45° C., which gives a sensation of heat to both hands, but this is less marked in the right hand than in the left hand. Water of 55° C. is decidedly hot to both hands, but this temperature is more painful to the right hand than to the left.

It will be seen from the above that the quality or quantity of the sensation produced by a given temperature when brought in contact with a healthy skin,and with the temperature apparatus healthy and intact, depends, to certain limits at least, on the temperature of the skin at the point tested. This principle has been elaborated and defended in detail by Hering as follows:

"As often as the thermic apparatus in any spot in the skin has a temperature which lies above its own zero point, we have a sensation of heat; in the contrary case, a sensation of cold. Either sensation is so much the more marked, or stronger, the more the temperature of the thermic apparatus at the time varies from the temperature of its own zero point. The zero point of any part of the skin is the exact objective temperature which at that point will produce no sensation of heat or cold."

It is obvious, however, from the preceding tests that contrast, relativity, and exhaustion must enter largely into the explanation of all these changes in the temperature sensations.

To determine the reaction time to heat and to cold, tests were made with ten different subjects, and the average reaction time of five different tests for each of the several different temperatures was noted. It was proven that the reaction time varied with different temperatures and from different parts of the body. It also varied with different individuals. Cold, as a rule, is felt quicker than heat. But this is due undoubtedly to the fact that the skin is a poorer conductor of heat than the metal that is used to make contact with the skin in making the tests, and consequently heat passes from the skin to the metal more readily than it passes from the metal to the skin. Consequently the nerves in the skin are stimulated quicker with cold than with heat.

The true reaction time or the time left after all sources of error are eliminated, is undoubtedly the same for sensations of heat and of cold of equal intensity.

Below is a table of the average reaction time of five sets of tests of five subjects, taken from five different parts of the body. The time is expressed in thousandths of a second in each test.

The electric chronometer of d'Arsonval was used in measuring the reaction time:

TABLE OF THE AVERAGE REACTION TIME TO COLD AT 0° C. OF FIVE DIFFERENT TESTS IN EACH OF FIVE DIFFERENT CASES FROM THE DIFFERENT PARTS OF THE BODY EXPRESSED IN THOUSANDTHS OF A SECOND.

	CASE 1.	CASE 2.	CASE 3.	CASE 4.	CASE 5.
From foot to hand	.234	.230	.138	.248	.396
From thigh to hand	.134	.170	.108	.230	.324
From abdomen to hand . . .	.176	.162	.126	.180	.180
From hand to hand	.180	.128	.126	.230	.206
From face to hand	.098	.128	.074	.168	.068

TABLE OF THE AVERAGE REACTION TIME TO HEAT AT 60° C. OF FIVE DIFFERENT TESTS IN EACH OF FIVE DIFFERENT CASES FROM THE DIFFERENT PARTS OF THE BODY EXPRESSED IN THOUSANDTHS OF A SECOND.

	CASE 1.	CASE 2.	CASE 3.	CASE 4.	CASE 5.
From foot to hand	.682	.204	.146	.334	.354
From thigh to hand	.428	.208	.180	.216	.240
From abdomen to hand . . .	.312	.148	.166	.144	.216
From hand to hand	.282	.156	.160	.204	.256
From hand to face	.164	.140	.122	.150	.126

SUMMARY.

The thermic mechanism is that part of the nervous system which takes cognizance of changes of temperature. It may be considered as made up of three parts; viz., an end organ, an afferent nerve, and a central nerve centre. The end organs are located in the skin and mucous membrane of the body. It is not yet proven that there is a definite temperature area on the cerebral cortex. The experiments of Dessoir would indicate that each center was a temperature center. There is only one kind of end organ which is capable of stimulation by "heat" and by "cold." The temperature end organs are not excitable to pressure and electricity.

Changes of temperature between 5°C. and 60°C. produce sensations of cold or of heat in all parts of the body with little or no pain. Temperatures below 5°C. and above 60°C. cause pain, in addition to sensations of cold or heat. This is when the tests are made with test-tubes containing water of different temperatures. When the whole hand is exposed, pain is caused by a temperature of 10°C. or below, and by a temperature of 50°C. or above. Between these two temperatures, heat and cold are felt, accompanied with little or no pain. The sensations of heat, cold, and pain caused by the different temperatures vary in different individuals and in different parts of the body of the same individual. They also depend upon the size of the surface stimulated, the period of irritation or stimulation, and upon the thickness, the conductivity, and the temperature of the skin.

The relative sensibility of the different parts of the body to heat and to cold is indicated by the shading in Figs. 1 and 2 shown on page 551. The parts most deeply shaded are most sensitive to both heat and cold.

In our ordinary experience sensations of heat in any part of the skin are induced:

1. By a checking of a radiation of heat in any part of the skin while the blood supply remains unaltered.

2. By contact with an object or medium of higher temperature.

3. By an increase in heat from the interior of the body, as in a local hyperæmia.

Sensations of cold are induced:

1. By an increase of convection of heat from the skin while the local supply of blood remains unaltered.

2. By contact with objects of the same objective temperature as the surrounding air, but which conduct heat more readily than the air.

3. By contact with an object or a medium colder than the skin.

4. By lessening of the interior warmth of a part, as by the contractions of the blood vessels which supply a portion of the skin.

The skin is most sensitive to changes of temperature near its own zero point.

When the whole hand is subjected to varying temperatures, changes of ½°F. to 1°F. may be detected near the zero point of the thermic apparatus in the skin.

The reaction time to heat and to cold varies with the temperature that is used in making the tests, with the part of the body tested, with the conductivity of the skin to heat, and with the conductivity to heat of the instrument used in making contact with the skin.

The principal reasons that we feel objects that are cold, when brought in contact with the skin, quicker than those that are warm, is that the skin, being a very poor conductor of heat, absorbs heat slowly from an object of a higher temperature than itself; while other objects, which are cooler, and which in nearly every instance are better conductors of heat than the skin, absorb heat quite readily from the skin, and hence a sensation of cold is felt at once.

The true reaction time to heat and to cold, or the reaction time after all sources of error are eliminated, is practically the same for sensations of heat and of cold of equal intensity in the same part of the body.

Whatever increase in the reaction time to heat or to cold there may be over the reaction time to touch, is due mainly, if not entirely, to the time occupied in raising the temperature of the skin in one instance, and lowering it in the other, to a point sufficiently far from the normal to produce a stimulation.